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In considering the problems foreign students have with the determiners "the," "a/an," "some," and "all" (for which zero-determiner may be substituted), the author observes (1) The semantic classifications of nouns often seem quite arbitrary to the foreigner. (2) There is always some minimal linguistic or situational context which must be specified if a sentence in which some given determiner, or determiners, occur is to be unambiguous. (3) There are numerous minimal contrasts which exemplify the various uses of determiners. (4) A specification of the various uses of both obligatory and optional determiners is not so complex as some grammar books would lead us to suppose. Assuming Bertrand Russell's definitions, the author formulates the concepts common to sentences involving the words "the," "a/an," "some," and zero-determiner. Examples are given to provide evidence for the "incompatibility of natural language and exact thinking," based on the following reasons: (1) It is awkward and confusing to represent variables in natural languages. (2) It is impossible to clearly separate names from descriptions. (3) Grammatical conventions result in the representation of the same concepts in different ways and different concepts in the same ways. The author concludes that natural language cannot be used in exact thinking or for the exact description of natural languages. (AMM)

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NATURAL LANGUAGE AND EXACT THINKING¹

Nancy L. Fargo

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¹ This paper was presented at a meeting of the Interdisciplinary Study Group on the Language Sciences, The Johns Hopkins University, Baltimore, Maryland, November 16, 1967.

NATURAL LANGUAGE AND EXACT THINKING

My interest in natural language and exact thinking arose in what might seem an unlikely context, the teaching of English as a foreign language. If you listen to foreigners who are learning English, you will hear sentences like the following:

From a Spanish student, for example - My father is professor.
From a Turkish student - Turkish Republic is my country.
From a French student - The Queen Elizabeth entertained yesterday.

If we contrast Spanish, Turkish and French with English, we understand at once the source of the errors. Turkish does not have words analogous to the, or a/an; Spanish and French do, but they do not use them in exactly the same way.

It is when we try to prevent or eliminate such errors, that we come face to face with a consideration of natural language and exact thinking. By exact thinking I mean formal reasoning, i. e. reasoning in which we determine the validity of an argument in virtue of its form, not in virtue of the meaning of any of the particular terms that occur in it. We could use alternatively the term mathematical reasoning, if we keep in mind that mathematical reasoning need have nothing whatsoever to do with number.

Now it is essential to mathematical reasoning that we define the nature of the variable, propositional functions, names, descriptions and descriptive functions, and classes. But if we are to do so in English, we will find ourselves involved in a consideration of the words the and a/an

together with some and all. That is to say, we will be analysing the very words which give so much trouble to foreigners who are learning English.

This fact suggested to me that it would be profitable to see just exactly how these words are used in English to represent concepts fundamental to mathematical reasoning. And in so doing I was lead to an examination of specific evidence for the incompatibility of natural language and exact thinking. It is this evidence that I would like to discuss with you this evening.

Though I have probably made it appear that I saw at once the relevance of the words the, a/an, some and all to formal reasoning, this was not the case. And so I would like first to share with you the observations that lead me to consider this relationship. Then, I will summarize what I have found out so far. From this point on, for convenience, I will follow current practice and call the words a/an, the, some and all determiners, noting in passing that other words, not relevant to tonight's discussion, are also members of this class. Also, I will no longer make specific reference to all. \emptyset , or quite literally nothing-at-all, is equivalent to this word (for example, coffee is delicious is equivalent to all coffee is delicious) and \emptyset is grammatically analogous to the other determiners in all respects, whereas all is not.

The first set of observations, observations which, to be sure, others have also made, are as follows: First, the semantic classifications of nouns which we sometimes set up in order to explain the use of determiners

often seem quite arbitrary to the foreigner. Take, for example, the semantic distinction between mass and count nouns. Mass nouns are said to be inherently uncountable, for example, water, milk and sugar -- and hence to have no plural form -- count nouns, inherently countable, for example, book, chair, and tree. With mass nouns, the rule generally goes, we may use the determiner some (I have some water) or no determiner at all (I have water); with count nouns, we may use the determiner a/an (I have a pencil) but if we use the singular form of the noun we can not omit a determiner altogether (I have pencil is ungrammatical); and we can only use some with the plural form of the noun (I have some pencils).

It is probably only when we ask someone who does not speak English natively to apply such a rule that we realize that the semantic classification on which it is supposedly based is at least as arbitrary as the distinction, say, between masculine and feminine nouns in French or Spanish. It may seem altogether obvious to a native speaker that pencil and crayon are count nouns while chalk is not (I have a pencil -- I have a crayon -- but not, of course, I have a chalk), but to a foreigner the distinction is mystifying. Or suppose we tell him that bean and lentil are count nouns, and that then, by what seems to him a valid analogy, he produces the sentence, I'd like some rices. I think at this point we would be prepared to consider that the apparent semantic basis for a distinction between mass and count nouns is quite elusive, even, I should say, illusory. And it seems to me that this is also true of other semantic classifications which have been thought helpful in teaching the correct use of determiners.

The second observation is this: there is always some minimal linguistic or situational context which must be specified if a sentence in which some given determiner, or determiners, occur is to be unambiguous. This is obvious. But I bring it up because, as Fries and others have shown, the search for ambiguities directs our attention to imprecise or incomplete formulations which might otherwise escape attention. By way of illustration, here is one such ambiguous sentence. You can readily decide what minimal changes would make it unambiguous. He stepped on the glass.

Next, there are numerous minimal contrasts which exemplify the various uses of determiners. This is also obvious but nonetheless important for two reasons: 1) the search for minimal contrasts, like the search for ambiguities, also directs our attention to imprecise or incomplete formulations. 2) Minimal contrasts show that there is much greater freedom of choice in the use of the various determiners than we might otherwise expect. A few examples will suffice.

I know Jacqueline Kennedy.
I know a Jacqueline Kennedy.
I know the Jacqueline Kennedy.

Queen Elizabeth arrived yesterday.
The Queen Elizabeth arrived yesterday.

He stepped on a glass.
He stepped on some glass.

The flowers are beautiful.
Some flowers are beautiful.
Flowers are beautiful.

Finally, a specification of the various uses of determiners, both obligatory and optional, is surely not quite so complex as some of our grammar books, both linguistic and traditional, would lead us to suppose. For otherwise even native speakers would be unable to master the system.

All the above lead me to ask three questions:

- 1) Is it possible to formulate precisely the concepts common to sentences involving the words the, a/an, some or Ø?
- 2) If yes, then, how, in given instances, do we express such concepts?
and
- 3) To what degree is the form in which we express them dependent on arbitrary grammatical classification?

To begin with the first question: Is it possible to formulate precisely the concepts common to sentences involving the words the, a/an, some or Ø? The answer is 'yes'. In fact Bertrand Russell does exactly this in his Introduction to Mathematical Philosophy, as a means of explaining the nature of the variable, propositional functions, descriptions and descriptive functions, and classes. And in what follows I will assume his definitions. It then remains to look at the form in which the concepts are expressed, in the course of which the degree to which form is dependent on arbitrary grammatical classifications will become apparent. A decision to follow this approach is a decision to look at the relevance of determiners to formal reasoning.

By a representation I shall mean an occurrence of a, the, some or Ø (i. e. nothing-at-all) followed by a singular or a plural noun. If you will

look at your handout (on the following page), you will see in the first column a list of the representations to which I will be referring. With each representation, we may associate different concepts. The concepts I will discuss tonight are listed in the second column of the handout, in the order in which I will bring them up. The particular concept we associate with some given representation depends on the linguistic context in which the representation occurs. By the linguistic context of a representation I mean all other elements, both grammatical and lexical, which co-occur with the particular representation. Thus, in the sentence Some cats meow, some cats is an instance of the representation some + Npl. and meow is the linguistic context in which this representation occurs. Examples of what I mean are given in Column 3 of the handout.

The first concept I will discuss is the concept term. By a term I will mean a word about which an assertion is made concerning some property of this word as a sound pattern or a visual pattern rather than an assertion about the sense-data or events to which the word has reference. The representation is always Ø + Nsg. (I should add, parenthetically, that any part of speech whatsoever can occur here, but as I have limited this talk to representations with nouns, I will not give examples with other parts of speech). The specification of linguistic context is crucial for, as we shall see, the representation Ø + Nsg. is associated with other concepts in other linguistic contexts. Tonight, I will simply give examples of linguistic contexts where we would associate the representation Ø + Nsg. with the concept term. Different contexts would result either in different associations or

<u>Representations</u>	<u>Concepts</u>	<u>Examples</u>
$\emptyset + \text{Nsg.}$ $\begin{cases} \text{Scott} & (1) \\ \text{cat} & (2) \\ \text{pencil} & (3) \end{cases}$	(A) Term	(13E) Some cats meow.
	(B) Unit Class	(7F) A cat is meowing.
$\emptyset + \text{Npl.}$ $\begin{cases} \text{cats} & (4) \\ \text{men} & (5) \\ \text{lions} & (6) \end{cases}$	(C) Name	(4E) Cats sometimes meow.
	(D) Description	(16H) The cat is meowing.
$a + \text{Nsg.}$ $\begin{cases} \text{a cat} & (7) \\ \text{a man} & (8) \\ \text{a pencil} & (9) \end{cases}$	(E) $(\exists x) \phi x \supset \psi x$	(7D) This is a cat.
	(F) ϕx	(4J) Cats meow.
	(G) $\phi x_1 \dots x_m$	(2A) <u>Cat</u> is a three-letter word.
$\text{some} + \text{Nsg.}$ $\begin{cases} \text{some chalk} & (10) \\ \text{some glass} & (11) \\ \text{some soap} & (12) \end{cases}$	(H) ϕa	
	(I) $\phi a_1 \dots a_m$	
$\text{some} + \text{Npl.}$ $\begin{cases} \text{some cats} & (13) \\ \text{some books} & (14) \\ \text{some glasses} & (15) \end{cases}$	(J) $(x) \phi x \supset \psi x$	
$\text{the} + \text{Nsg.}$ $\begin{cases} \text{the cat} & (16) \\ \text{the chalk} & (17) \\ \text{the man} & (18) \end{cases}$		
$\text{the} + \text{Npl.}$ $\begin{cases} \text{the birds} & (19) \\ \text{the glasses} & (20) \\ \text{the books} & (21) \end{cases}$		

ungrammatical sentences. For example, compare the sentence 'Rice' is a noun with, say, Rice is a staple, in which we have identical sentence patterns, but a different association, owing to the lexical contrast between noun and staple. Or compare 'Rice' is a noun with Rice is delicious. To my knowledge, the concept term can not be represented in the second pattern, i. e. the pattern N + 'be' + Adj. Next, compare the sentence Lentil is a noun with the sentence Lentil is a staple, which, unlike our previous sentence, Rice is a staple, is ungrammatical. Other examples where the association term is appropriate are the word 'lecture' and the variable 'x'. Here, the relevant feature of the linguistic context is that the term word be preceded by an appropriate noun. If it is preceded by an adjective, say, the wordy lecture, we no longer have a ∅ representation at all and the association of course changes.

Except for the above case, there is more than one representation for any given concept, and the choice of representations is restricted by certain arbitrary noun classes. The two most important classes, which for convenience I will simply call class 1 and class 2, are mutually exclusive classes, and all English nouns belong either to the one class or to the other. Any other noun classes which I mention will be sub-classes of one of these two classes. The diagnostic frame I have used to sort nouns into the two classes is the sentence pattern N + 'be' non-past + Adj. Any noun which can occur without a determiner in this test frame will belong to class 1; any noun which must occur with a determiner (either the

ones we are discussing tonight or some other determiner) in this test frame will belong to class 2. To point up what seems to me the arbitrariness of assignment to membership in the two classes, I have purposely selected examples which seem to me quite closely related semantically. The first example will always be a class 1 noun; the second, a class 2 noun.

<u>Chalk is useful.</u>	but not	<u>Pencil is useful.</u>
<u>Information is important.</u>	but not	<u>Fact is important.</u>
<u>Home is nostalgic.</u>	but not	<u>House is nostalgic.</u>
<u>School is interesting.</u>	but not	<u>University is interesting.</u>
<u>Man is inquisitive.</u>	but not	<u>Boy is inquisitive.</u>
<u>Manhattan is dirty.</u>	but not	<u>Bronx is dirty.</u>

Having made this class distinction, I can now talk about the remaining concepts. The next concept is that of unit class, that is a class which has one and only one member. If we wish to name such a class, without describing it, the representation is $\emptyset + \text{Nsg.}$ if the noun is a class 1 noun (Manhattan); the + Nsg. if the noun is a class 2 noun (the Bronx). If we wish to describe the class, without naming it, the representation is the + Nsg. Naming and describing are both illustrated in Russell's famous example Scott is the author of Waverly, where Scott names and the author of Waverly describes. What are commonly called 'proper names' can be used to name a unit class, but any other noun could be used as well; at the same time there is no grammatical class 'proper names' whose members always name unit classes, and which therefore always occur without a determiner, as the contrasts given earlier clearly show: I know Jacqueline Kennedy, I know a Jacqueline Kennedy, I know the Jacqueline Kennedy.

We have in English an intermediate case where we both name and describe, e. g. President DeGaulle, in which case we use alternatively the representation $\emptyset + \text{Nsg.}$ and the + Nsg. With class 1 nouns the representation is $\emptyset + \text{Nsg.}$ (President DeGaulle) but with class 2 nouns, both representations are used and the choice appears to depend on an arbitrary sub-classification of class 2 nouns. Thus we say Dupont Circle but The Washington Monument.

It is interesting to compare our grammatical conventions in this respect with those, say, of French, where the grammatical representation for simple naming is the same for the designation of individuals but not otherwise--De Gaulle but la France; the same for a description -- le President de la France--but different again for the intermediate case, i. e. both naming and describing, where in French the definite article is always used, i. e. there is no sub-class of nouns requiring a different representation. So we have in French le President De Gaulle and le President de la France.

It is also interesting to note that in English the representation of a unit class contrasts with that of a class with more than one member, and that the same class can be alternatively designated a unit class and a class with more than one member: America or the United States, Holland or the Netherlands. In French or Spanish, both cases would be represented in the same way, the distinction still having a grammatical correlate however, since the definite article has both a singular and a plural form in those languages.

The other concepts I wish to discuss are, I think, rather simpler and can be made clear almost wholly by examples. The first is expressed by the formulation: $(\exists x) \phi x \supset \psi x$. With class 1 nouns, the following representations are used:

\emptyset + Nsg.	Glass is sometimes fragile.
\emptyset + Npl.	Glasses are sometimes fragile.
a + Nsg.	A glass is sometimes fragile.
some + Nsg.	Some glass is fragile.
some + Npl.	Some glasses are fragile.

With class 2 nouns:

\emptyset + Npl.	Books are sometimes interesting.
a + Nsg.	A book is sometimes interesting.
some + Npl.	Some books are interesting.

but not \emptyset + Nsg. or some + Nsg. The very same representations will be interpreted as simply asserting ϕx or $\phi x_1 \dots x_m$ if we change the linguistic context. Compare, for example: Some birds talk with Some birds are talking.; A baby cries with A baby is crying.

If, however, we wish to make an assertion of the form ϕa or $\phi a_1 \dots a_m$, i.e. if we wish to assign some definite value to a variable, both the representation and the linguistic context must change. In this case, the representation is the + Nsg. or the + Npl., and it is not necessary to specify whether the noun is in class 1 or class 2.

The glass is empty.
The glasses are empty.
The babies are crying.
The cheese is delicious.
The cheeses are delicious.

This contrast in representation between ϕx and ϕa is the way in which we keep track, in English, of how many individuals or collections of individuals

have been identified. Compare, for example, the pair of sentences:

A policeman was standing on the corner.
A policeman was wearing white gloves.

with the pair of sentences:

A policeman was standing on the corner.
The policeman was wearing white gloves.

or

The children are playing in a park.

with

The children are playing in the park.

The last concept I would like to talk about is that expressed by the formulation: $(x) \phi x \supset \psi x$. With both class 1 and class 2 nouns this concept can be represented by

- | | |
|------------------------|---|
| (1) a + Nsg. | A work of art is pleasing.
A lion is a mighty hunter. |
| (2) the + Nsg. | The man who works hard achieves much.
The lion is a mighty hunter. |
| (3) \emptyset + Npl. | Schools are important.
Universities are important. |

but only with class 1 nouns do we find this concept represented by \emptyset + Nsg. --

Man is inquisitive., but not, as we said earlier, Boy is inquisitive.

Once again, linguistic context is crucial in determining what concepts will be associated with particular representations, and the permissible choices among representations--thus both Flowers that bloom in the spring are beautiful. and The flowers that bloom in the spring are beautiful. can be associated with the concept $(x) \phi x \supset \psi x$; but Flowers are beautiful. is

associated with the concept $(x) \phi x \supset \psi x$ whereas The flowers are beautiful. is associated with the concept $\phi a_1 \dots a_m$. We can use the representation $\emptyset + \text{Nsg.}$ in the sentence Work is rewarding. to mean $(x) \phi x \supset \psi x$ whereas A work is rewarding. is ungrammatical. But if we substitute the phrase work of art, the representation $\emptyset + \text{Nsg.}$ is no longer grammatical, and we must say either A work of art is rewarding. or Works of art are rewarding.

Now in what way do all the above examples provide evidence for the incompatibility of natural language and exact thinking?

To begin with the obvious, it is both awkward and confusing to represent variables in natural languages. In other words, it is almost impossible not to have reference to particular things or particular properties; whereas in formal reasoning we wish to deal with what can be said about any thing or any property. This difficulty probably accounts for the fact that traditional logic regarded All men are mortal. as of the same form as Socrates is mortal., although they make fundamentally different assertions.

Secondly, it is impossible to clearly separate names from descriptions. In a natural language, except for words like this or that, all names are really abbreviated descriptions. When we say or write the word DeGaulle, we may wish to use this word as a simple name, but in fact it evokes for each of us different images, and is thus an abbreviated description for the present president of France.

Thirdly, grammatical conventions result in the representation of the same concepts in different ways, and different concepts in the same way.

Thus we can say Men are inquisitive. and Boys are inquisitive.; but while we can say, to mean exactly the same thing, Man is inquisitive. we can not say Boy is inquisitive. Or consider the sentence Man is a predator.; if we substitute lion for man, and wish to express the same meaning, we must now use the representation a + Nsg. or the + Nsg. -- A lion is a predator. or The lion is a predator., for Lion is a predator. is not grammatical. And yet, with both lion and man, we can represent the concept by Ø + Npl., i. e. we can say both Men are predators. and Lions are predators.

Certain notions can not be represented in natural language at all without leading to what Russell calls an "intolerable prolixity." The logic of classes, for example, can only be hinted at. Thus, in natural language we are driven to use the same expression, say a man, to designate a class concept, e. g. Socrates is a man., an instance of the class, e. g. This is a man., and to both name and describe a class, A man's a man for all that.

To sum up, in natural language it is virtually impossible, to quote Eddington, to "detach structural knowledge from knowledge of the entities forming the structure." Yet just such detachment is essential to formal reasoning as I defined it at the beginning, viz reasoning in which we determine the validity of an argument in virtue of its form, not in virtue of the meaning of any of the particular terms that occur in it. In other words, natural language can not be used in exact thinking; and in particular, natural language can not be used for the exact description of natural languages.

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ANNUAL REPORT

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